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FOREIGN TECHNOLOGY DIVISION

ON THE FUNDAMENTAL POSSIBILITY OF DECREASING THE INFLUENCE OF THE ATMOSPHERE ON THE IMAGE OF A STAR

By

V. P. Linnik

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EDITED TRANSLATION

FTD-ID(RS)T-0714-79 31 May 1979

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А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh^{-1}
cos	cos	ch	cosh	arc ch	cosh^{-1}
tg	tan	th	tanh	arc th	tanh^{-1}
ctg	cot	cth	coth	arc cth	coth^{-1}
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

ON THE FUNDAMENTAL POSSIBILITY OF DECREASING THE INFLUENCE OF THE ATMOSPHERE ON THE IMAGE OF A STAR

V. P. Linnik

It is well known that the influence of the atmosphere's optical heterogeneity (atmospheric turbulence) on the image of a star in an astronomical telescope increases very strongly with an increase in the diameter of the telescope objective lens and, in essence, sets a limit to the resolution of large instruments. If rather many nights with good image quality exist for instruments with an aperture of 10-20 cm, there are now few such nights for instruments with an aperture greater than one meter and for the 5-meter Palomar telescope there are hardly atmospheric conditions under which its resolution could be completely utilized. This means that a flat light wave which arrives from the star to the objective lens is distorted while passing through the atmosphere. Depending on the condition of the atmosphere, a more or less considerable area of the wave is distorted in which regard these deviations from the plane are very small. The shape of the wave varies with time; however, during a period of 1/10-1/20 s these changes are insignificant. Hence it follows that if the mirror of the telescope could be distorted with sufficient speed so that its distortion compensated for the change in the shape of the light wave and made it flat, then we would constantly have an ideal image of the star in the mirror focal point.

In sites which have been specially selected for the installation of large telescopes, there are a considerable number of nights during which the images of stars which can be observed in the telescope with an objective lens having a diameter of 20 cm possess clarity and stability which are ideal for this image. If, under such conditions, we divide a wave which is arriving from a star into sections with an area of 20 x 20 cm, the total picture can be presented in the following manner: we have a flat wave on each section; however, different sections differ from each other for phase, in general the further they are from one another the greater the difference.

The possibility of compensating for atmospheric turbulence follows from this. Let us divide a telescope mirror which is directed at a star into sections on the order of 20 x 20 cm and let us create the possibility for their very small parallel displacement relative to one another along the normal depending on the electric voltage applied to them. We tap a small portion of the total pencil of rays into a system which shows the deviation of the phase of the wave part which is incident to each 20-centimeter section from the phase of an ideal wave. We set up a photoelectric system which automatically measures the phase difference on each section of the wave and transmits a voltage which is proportional to this phase difference to the corresponding section of the mirror. Then the telescope will provide an undistorted image of a star with the presence of optical heterogeneities in the atmosphere as well as within the system and the dome.

Let us examine in greater detail the possibility of implementing this scheme. First of all, in order to divide a light wave into small sections there is no necessity to divide the principal mirror of the telescope into sections. This division can be accomplished just as successfully on any image of an entrance pupil or, in view of the very low utilization of the field, simply on any mirror which is placed in the path of the rays.

Let M be the main mirror of a telescope (Figure); the light rays from the star, reflected from it, land in the second mirror N which is placed not far from the focal point of the main mirror. The mirror N which is small in dimensions is divided into a number of sections which can shift relative to one another along the normal proportional to the electrical voltage which is applied to them. The mechanism for the accomplishment of such a shift can be made using the piezoelectrical principle or in accordance with the scheme which uses a change in the mutual attraction of two opposite surfaces with a change in the voltage applied to them. Here, it should be considered that in general the displacement of the mirror sections under the influence of a change in voltage will not exceed one micron.

After reflection from the mirror N a large portion of the light from the star passes through a dividing plate D to the focal point of the telescope F while a smaller portion is reflected from plate D and lands in an interferometer I.

The purpose of the interferometer is to create an interference picture on the image P of the telescope's input pupil which characterizes the distribution of the difference in the travel between a wave which is incident to the mirror M and an ideal wave.

An interferometer screen is possible, for example, in which a magnified image of one of the sections into which the mirror N is divided is superimposed on the image P of the pupil. Other schemes are also possible. As a result, we can create an interference picture where the distribution of brightness across the pupil provides information about the shape of the wave surface which is incident to the mirror M.

Assume that on each section of the image P there stands a photocell which provides a current proportional to the illumination of this section. Commutation is also completely possible in which the brightness condition on a given element as well as on a number

of others will provide a command to the movable section of the mirror N to give it the shape which compensates for the irregularity of the wave which has arrived from the star to the main mirror M.

The direction of the required displacement of the mirror section is determined by the direction of movement of the reference plane with which the latter encounters the zero band for a given section. The question of the zero band in this case is very important, and therefore the photocells which are employed here should have a broad spectral region of sensitivity. By the way, it is completely possible that the employment of a combination of two photocells, for example the FEU-19 and FEU-22, will provide the opportunity to detect the zero band clearly.

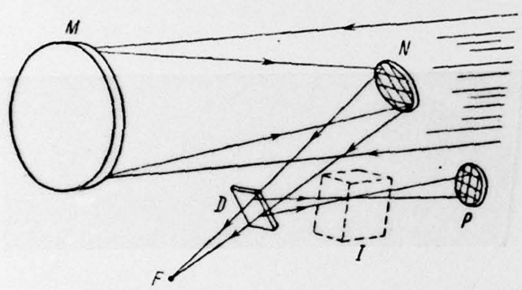

Fig. 1.

If we assume that the shape of the wave surface is preserved for about 1/10-1/20 s, then a photoelectric scheme is conceivable in which the accumulation of information about the shape of the wave occurs during this time and then the corresponding correction of the surface N occurs during 1/100 s.

The system which has been described will provide the opportunity to obtain the clear image of the star, which is provided by a telescope mirror with a size of several meters, on the slot of a spectrograph with a small aperture ratio and complete utilization of the light, which is important for photographs with large dispersion.

This same system can be used to observe and measure close double stars with a very large difference in brightness and, in general, to observe those pairs which now cannot be distinguished either in large telescopes or using interferometers.

Finally, with further development of aviation technology, to control the mirror N it will be possible to create an artificial luminous point which is located at an altitude of 8-10 km, in which regard its displacement will be controlled from the earth by an observer at a telescope and it will be possible to bring this luminous point to coincidence with any star. Here, the possibility would arise to utilize the resolution of a large telescope completely to observe the surface of planets and to solve other similar problems.

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